

CLAIMS

Claim 1. An apparatus for active in situ multi-element gas sparging for accelerated bioremediation or for removal of contaminants in a soil formation containing a subsurface groundwater aquifer, the multi-gas contained in bubbles, said apparatus comprising;

- a) a plurality of injection wells each having casing means extending to a depth of a selected aquifer;
- b) means for providing an oxidizing agent;
- 5 c) means for sizing bubbles;
- d) means for controlled mixing of ambient air with said oxidizing agent;
- e) means for controlled mixing of ambient air with said oxidizing agent comprising ozone to provide a multi-element gas;
- 10 f) means for injecting said multi-element oxidizing gas in said aquifer comprising a plurality of microporous diffusers, without applying a vacuum for extraction biodegradation by-products, wherein said diffusers form micro-fine bubbles containing said multi-element gas that oxidizes in a gas/gas reaction, by stripping, chlorinated hydrocarbons from the aquifer; and
- 15 g) agitation means (pulsing or surging) for intermittently agitating water in the well effective to alter the path of micro-fine bubbles through a porous formation whereby enhanced contact between the oxidizing agent contained in each said bubble by stripping pollutant from solution in ambient water into the mini-atmosphere of each bubble for gas/gas reaction is effective to increase the efficiency and speed of remediation of a site.

20 Claim 2. The apparatus of claim 1 wherein the means for injecting said multi-element oxidizing gas in said aquifer comprises a microporous diffuser for producing bubbles configured to be a direct substitute for a well screen with 30% porosity 5-50 micron channel size resistance to flow only 1 to 3 PSI, capable of handling high volume flow, in combination with a selected annular

pack means (sized to formation by means of a test means); said diffuser positioned on end of pipe riser means to reduce residence time in the riser volume; wherein the size of the micro-fine bubbles is as set forth in the following table:

5 SIZE OF BUBBLES

| | BUBBLE DIAMETER | UPWARD VELOCITY IN WATER | TIME (MINUTES) FOR UPWARDS MIGRATION (3 METERS) (Coarse Sand and Gravel) |
|----|--------------------|--------------------------------|--|
| 10 | 10mm | .25 m/s | 19 min |
| | 2mm | .16 m/s | 30 min |
| | .2mm | .018 m/s | 240 min |

15 Claim 3. The apparatuses of claim 1 wherein the agitation means for intermittently agitating water in the well effective to alter the path of micro-fine bubbles through a solid formation comprises a submersible pump.

Claim 4. The apparatuses of claim 1 wherein the means for sizing micro-fine bubbles micro-fine bubbles containing encapsulated gas means comprises a fine bubble production chamber contained in said casing means of each injection well.

20 Claim 5. The apparatuses of claim 4 including the employment of specially-designed wellheads to equalize injected flow between formation of differing permeability.

Claim 6. The apparatuses of claim 4 including the use of alternating pumpage and bubble injection to maximize dispersal of bubbles within and outward from specially-designed well casing containing a fine bubble production chamber.

25 Claim 7. An apparatus for active in situ multi-element gas sparging for bioremediation for removal contaminants in a soil formation containing a subsurface groundwater aquifer, the multi-gas contained in bubbles, said apparatus comprising:

- a) a plurality of injection wells extending to a depth of a selected aquifer;
- b) means for providing an oxidizing agent;
- 30 c) means for controlled mixing of ambient air with said oxidizing agent to provide a multi-element gas;

d) means for injecting said multi-element oxidizing gas in said aquifer comprising a plurality of microporous diffusers, without applying a vacuum for extraction biodegradation by-products, wherein said diffusers form micro-fine bubbles containing said multi-element gas that oxidizes, by stripping, chlorinated hydrocarbons from the aquifer and surrounding saturated soil formation into harmless by-products;

e) agitation means for intermittently agitating water in the well effective to alter the path of micro-fine bubbles through a solid formation whereby enhanced contact between the oxidizing agent contained in each said bubble by stripping pollutant from solution in ambient water into the mini-atmosphere of each bubble effective to increase the efficiency and speed of remediation of a site.

Claim 8. The system of claim 9 wherein the diffuser means comprises HDPE porous material with well fittings and pass-through design which allows individual pressure and flow control wherein horizontal sparging is permitted with even distribution of air bubbles.